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THE REGIONAL SURVEY OF FOREST INSECT CONDITIONS
CALIFORNIA REGION
1931 - 1936

by
K. A. Salman

INTRODUCTION

In 1931, the work of surveying insect-caused losses in the ponderosa pine timber stands of Region 5 (California and parts of Nevada) was organized as a major project of the Berkeley Laboratory of the Bureau of Entomology and Plant Quarantine under the title "Regional Survey of Forest Insect Infestations and Trends". The project plan was more ambitious, complete and extensive than any that had been developed previously for forest insect surveys in the California region. It called for a more exact sampling of infestations, a great extension of the area sampled, and a continuity of records. It was hoped that, in addition to losses in ponderosa and sugar pine reserves, those in fir and in other important forest types eventually could be included in the information secured by the survey.

The regional survey project is not an attempt to control forest insects in California. It is an attempt to open up the problem, determine where, when, and how much timber is destroyed, examine the changes in infestations that occur from year to year and determine the extent of the damage and its seriousness under different conditions. Once these points are understood the control phase can be attacked in a logical manner on the basis of a clear understanding of the size and location of the problem.

A report on the work that was done during the 1931 season was presented in January, 1932 (1). Since that time no general report on the results of the survey work has been written. This paper reviews the forest insect conditions in the several areas that have been included in the surveys, presents some of the records, analyzes infestation trends and proposes a program.

ORGANIZATION OF THE SURVEY

The primary basis for estimates of insect-caused losses in infestation units, management units, subregions, or for the region as a whole, is secured by cruising losses on selected plots. Most of the plots are 320 acres in size. They have been selected to be representative of and to sample about 1,250,000 of the 6,818,000 acres of commercial pine type in the state. Reconnaissance cruises and observations are used to extend the application of the sample to other timbered acreage. Interpretations of infestation trends are secured by studying the changes in amount of loss, the characteristics of infestations and the relative importance of insect species in the year-to-year record.

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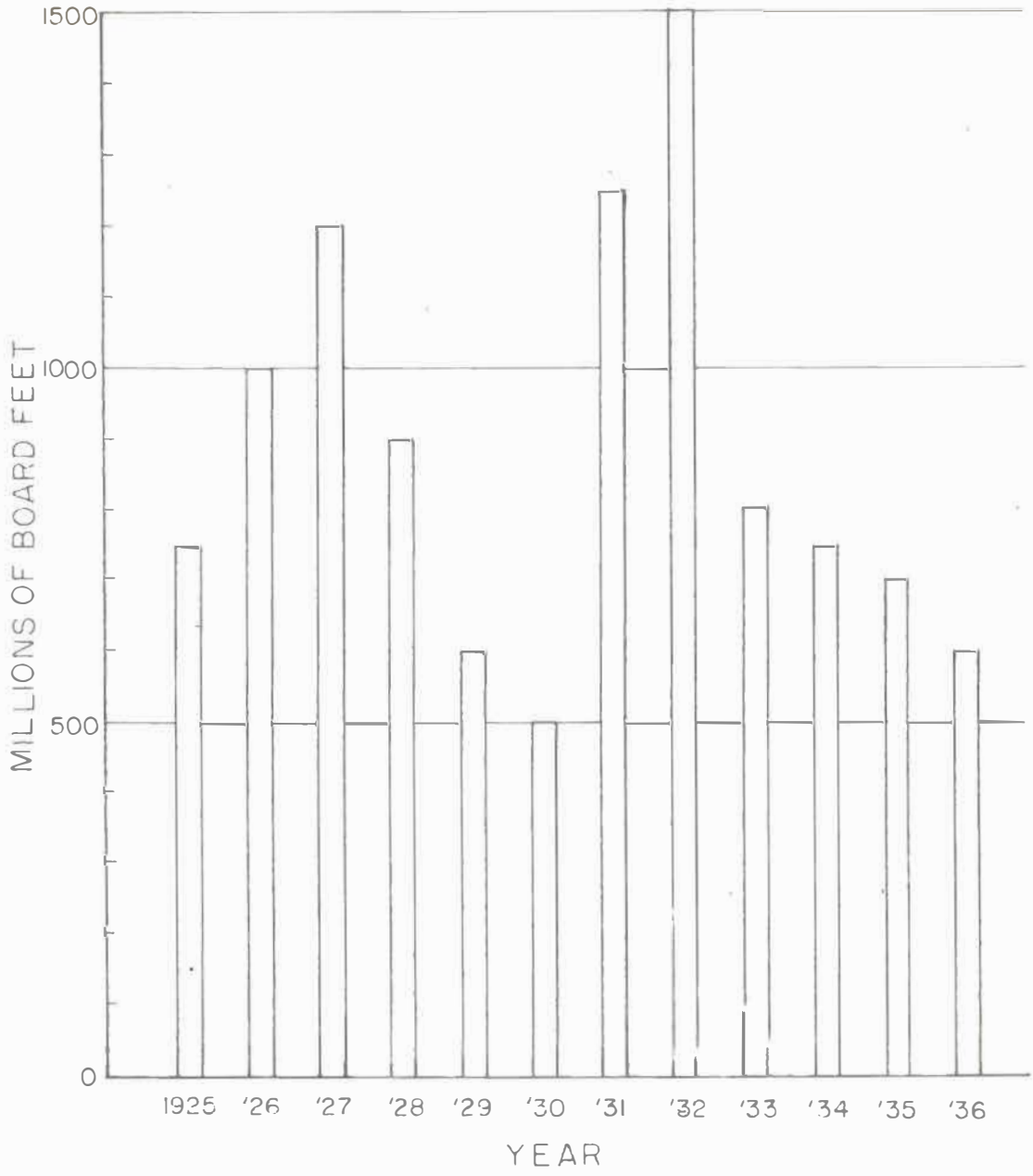
1. Miller, J. M. and K. A. Salman. Results and Recommendations, Forest Insect Survey, Region 5. Season of 1931. January 8, 1932.

FIG. 1

ANNUAL LOSS FROM FOREST INSECTS

IN CALIFORNIA



For the most part the surveys have recorded the damage that is caused by several species of barkbeetles that attack and feed on ponderosa, Jeffrey, sugar and lodgepole pine. Losses in white and red fir are considered, but the sample of the fir type is small. The records of a single year present the losses that result from the activities of all of the insect species, from the interactions between the several species or from the action of environmental factors in determining the degree of success or failure of broods. Series of successive annual surveys records show the year-to-year variations in the net effects of those activities.

SURVEY RESULTS

THE REGIONAL RECORD

In 1928, Keen estimated that the average annual insect-caused loss in the pine stands of California was 500,000,000 board feet. Heavier than normal losses had been recorded for several years previous to 1928. Since that year abnormal environmental conditions and excessive insect activity has been the cause of maintaining the loss above the average in every year except 1930. The regional loss record, which is shown in Figure 1, is as follows:

REGIONAL LOSS RECORD

Year	B.M. Destroyed
1925	750,000,000
1926	1,000,000,000
1927	1,200,000,000
1928	900,000,000
1929	600,000,000
1930	500,000,000
1931	1,250,000,000
1932	1,500,000,000
1933	800,000,000
1934	750,000,000
1935	700,000,000
1936	600,000,000 (tent.)
Total - 12 years	10,550,000,000

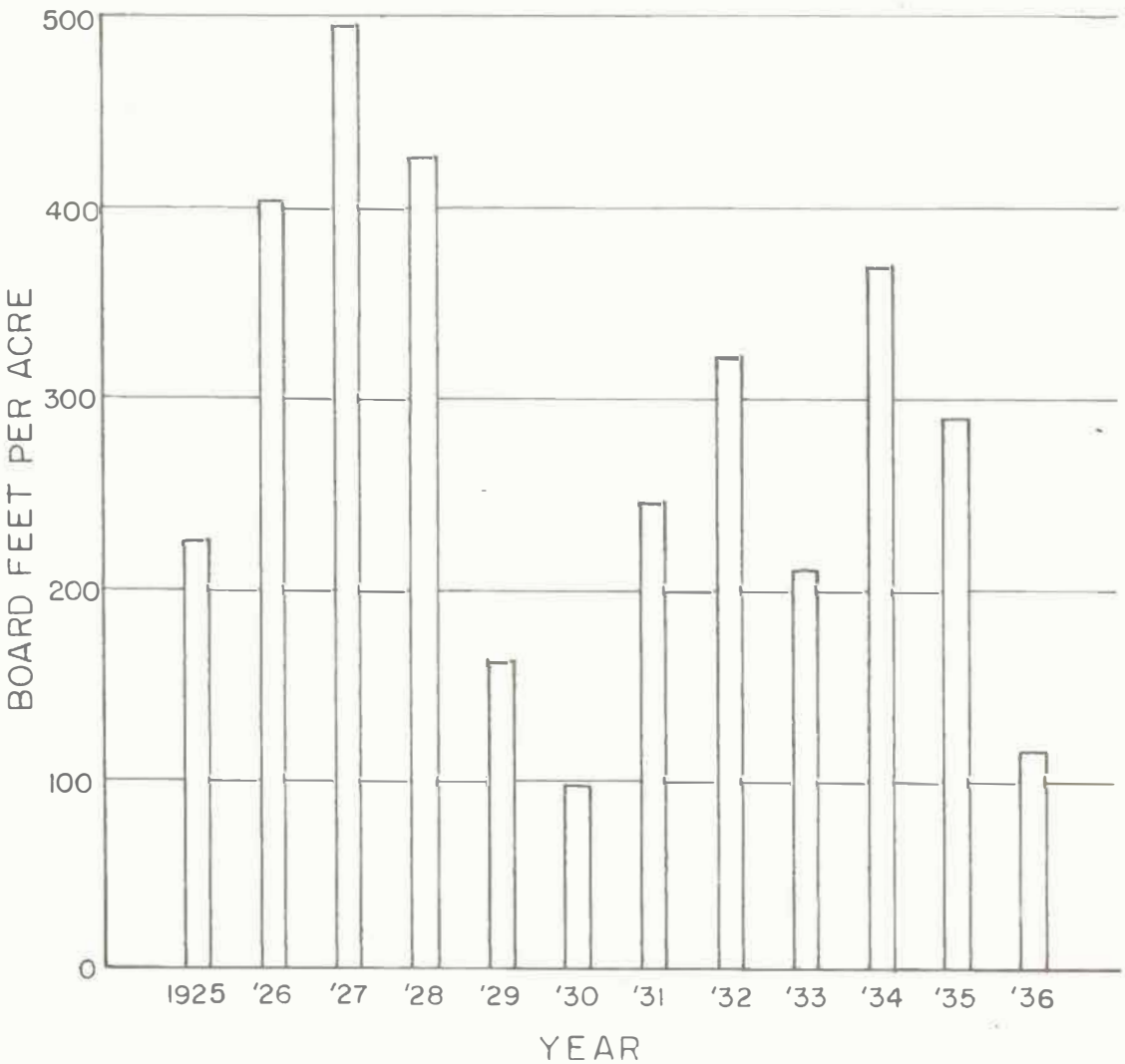
From 1925 through 1935, forest insects killed and removed from possible use in manufacture an estimated volume of nearly ten billion board feet of merchantable timber. During the same period the entire cut of all tree species in California, including redwood and some other species that are relatively immune to insect attack, was only about 16, 134,000,000 board feet. In other words, there has been one board foot of timber destroyed by insects in the forests of Region 5 for every 1.7 board feet that has been utilized.

During the six year period of 1930 through 1935, forest insects destroyed 5,500,000,000 board feet of timber. Fire destroyed but 534,050,000 board feet of merchantable and mature timber. Only about 3,760,000,000 board feet of ponderosa and sugar pine were cut and utilized during the same period.

FIG. 2

HAPPY CAMP - LAVA BEDS LOSS RECORD

MODOC NATIONAL FOREST, CALIFORNIA



Two very definite periods of high loss are visible in the record. In one respect those periods represent general increases throughout the state. However, they are a composite of outbreaks of very different intensity that were typical of eastside or westside stands. The differences were fairly widespread and can be considered to be subregional trends.

SUBREGIONAL LOSS RECORDS

Eastside Subregion

This subregion includes the areas and stands in Northeastern California and those east of the Sierra Nevada Range. In many parts of the subregion, losses during the past twelve years have been consistently greater, often much greater, than the amount of timber that has been added to the trees by growth. In some parts of the subregion the stands have suffered depletions of from 30 to 60%. The average depletion in several large and accessible commercial stands is not less than 30%.

Happy Camp - Lava Beds Area - Modoc National Forest

The infestation trends in this area, which are given in Figure 2, are fairly typical of those of the subregion. Average cruised losses are as follows: -

PLOT LOSS RECORD
Happy Camp - Lava Beds Area

Year	B.M. Destroyed per Acre
1925	225.6
1926	401.9
1927	494.7
1928	426.7
1929	161.9
1930	96.6
1931	245.7
1932	311.5
1933	211.7
1934	369.8
1935	289.3
1936	113.7 (tent.)
Total - 12 years	3,349.1

The first cycle of epidemic infestations started in 1925 following the extremely dry season of 1924. The western pine beetle became extremely active in attacking and causing the death of large groups of trees. Losses increased until 1927 and 1928, at which time the peak of the infestation cycle was reached. Late in the 1928 season a natural breakup of the infestations occurred and a considerable decrease was noted. During the next two years western pine beetle activity decreased while that of other species, chiefly flatheaded borers, increased in relative importance. Symptoms of renewed

activity were noted in July, 1931. The records that have been taken since that time show that the symptoms were the first indications of a new cycle of epidemic infestations. The amount of loss, the activity of the western pine beetle and the size and number of groups of infested trees became greater during 1931 and 1932. However, low temperatures that occurred during December, 1932 and February, 1933 gave the infestation a distinct setback by causing the death of the larger portion of the barkbeetle population in the area. A rapid recovery was made during the 1933 season and the cycle continued to develop until losses reached another peak late in 1934, or early in 1935. During 1935 there was a distinct drop in activity and losses in the marginal areas. However, in some of the better site areas grouping of infested trees, great activity on the part of the western pine beetle, and heavy losses continued until early in 1936.

At no time during the entire period of record have losses on the Happy Camp-Lava Beds area been less than twice the estimated amount of increment. The average annual loss for the entire period has been about 270 board feet per acre per year.

It is impossible to make any long range forecasts concerning future forest insect infestations in this area. Sudden fluctuations are possible. The effects of future environmental conditions cannot be determined. It is not known when or if the amount of loss will fall below the amount of increment.

Our present basis for making short range forecasts has not yet received an adequate test. However, indications are that, during 1937, the amount of loss will continue to decrease or will remain about the same as in 1936. It is to be expected that the western pine beetle will be less active, other species of forest insects will be relatively more important and that there will be a greater degree of selection of weakened or susceptible types of trees for infestation. However, it also has been observed that activity by other species of forest insects already has prepared the basis for a sudden increase, should other factors favor the western pine beetle.

Cutover Areas - Shasta National Forest

Between 125,000 and 150,000 acres of cutover lands are sampled by plots that have been established in the vicinity of Andesite, Tennant, and Red Rock Valley. The plots are situated both within and outside the northern boundaries of the Shasta National Forest.

The survey record shows that, in general, the infestation trends on the cutover areas have been similar to those in nearby virgin stands. Peak losses occurred in 1932 instead of in 1934, as was found to be the case in the Modoc areas. Since 1932, the trends have been downward, although estimated losses for 1936 are at the relatively high level of 36 b.m. per acre on the plots. That figure is about 2.5% of the stand. The average annual loss during the past five years has been 3.5% of the stand.

It is believed that infestation trends will continue to be downward during 1937. However, conditions are so extreme in many portions of the cutover area that relatively heavy losses in the reserve may be expected to continue for some time although typical epidemic infestations may not occur.

Fall River Unit - Shasta National Forest

Since 1932, loss figures have been secured for an area of about 139,000 acres situated near Burney, Dana and Fall River Mills. Examination of those figures and intimate knowledge of infestation conditions from year to year has lead to the conclusion that the factors influencing losses in this area are not definitely those of either the eastside or westside subregions. Forest Insect control and salvage logging projects have influenced the infestation trends and may have obscured the natural record in some parts of the unit.

Lethal temperatures during the winter of 1932-33 resulted in a considerable population reduction. However, a marked recovery occurred in 1933 and losses were heavy in 1934. A sudden reduction of losses on all plots occurred in 1935 but increased insect activity in the better quality stands resulted in a slightly larger loss estimate for the 1936 season. The record for this unit is as follows: -

PLOT LOSS RECORD
Fall River Unit

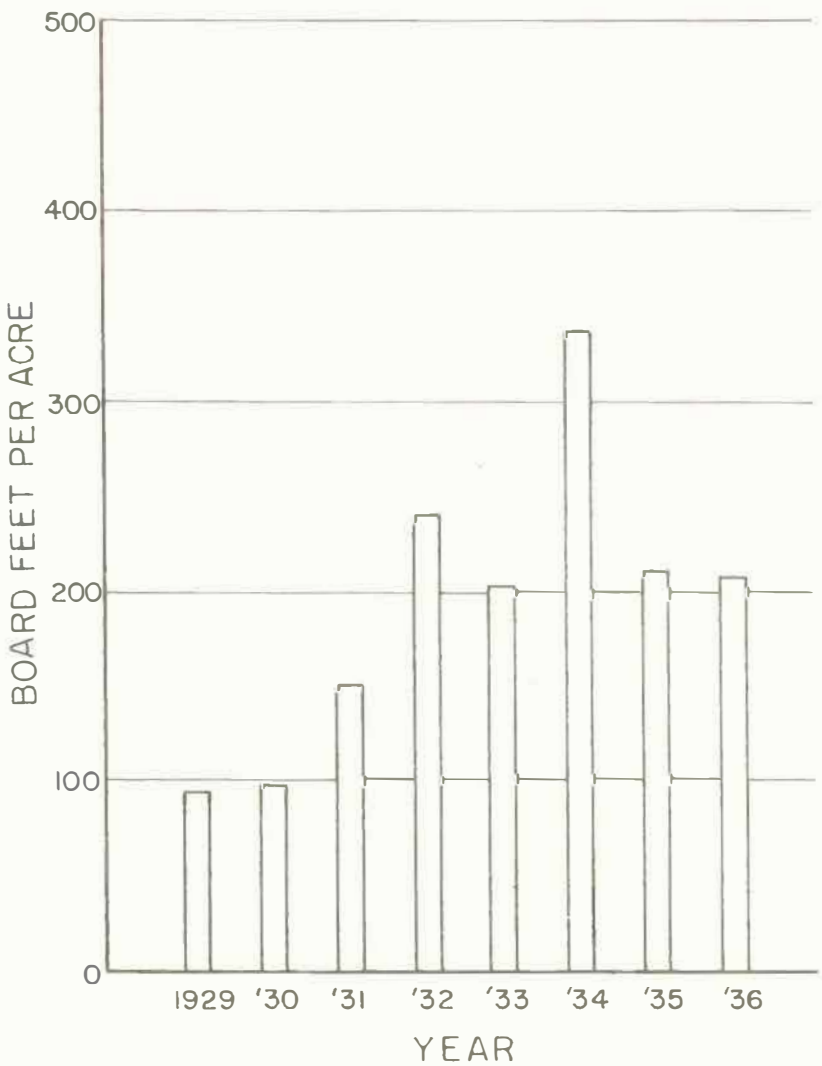
Year	B.M. Destroyed per Acre
1931	146.0
1932	197.6
1933	94.9
1934	150.3
1935	59.5
1936	65.0 (Tent.)
Total - 6 years	713.3

This record illustrates the buildup of epidemic infestations until the winter of 1932. Large groups of trees were infested in that year - even in the better quality stands. However, since 1932 no typically epidemic infestations have occurred. Rather it can be considered that the losses are those resulting from the weeding out of weakened or decadent trees in overmature virgin stands on the better sites, or the results of continued environmental pressure on the intermediate and fringe stands. It is to be expected, judging from present indications, that losses will continue for another year, with minor fluctuation, about as they have been recorded for the past two seasons. It is evident that, although these relatively low losses may merely reduce the net gain due to increment in the better quality stands, they are resulting in an often considerable net depletion in many stands of intermediate to poor quality.

FIG. 3

EASTERN LASSEN WORKING CIRCLE LOSS RECORD

LASSEN NATIONAL FOREST, CALIFORNIA



Eastern Lassen Working Circle - Lassen National Forest

Over 300,000 acres of timber land in private and government ownership are included in the surveys of this management unit. The loss record, which is given in Figure 3 and in the following table, shows the infestation trends during the period of survey.

PLOT LOSS RECORD
Eastern Lassen Working Circle

Year	B.F. Destroyed per Acre
1929	95.2
1930	97.8
1931	150.5
1932	241.2
1933	202.8
1934	335.0
1935	211.3
1936	206.9 (tent.)
Total - 8 years	1,540.7

This record, although it shows the general trends of infestation in the management unit as a whole does not show the exact trends in the diverse types of stands and conditions that are included in the unit. The 1932 peak losses and the 1933 depression, are to be found in the loss records of all infestation units except Gordon Creek, Bogard and Butte Creek. In those areas the increase in infestation intensity has been consistent from the start of the record to and including 1935. This has chiefly been due to the gradual extension of heavy loss conditions into the main timber body.

In most of the infestation units the heaviest loss occurred in 1934. In many areas, such as Little Valley, Dixie Valley and Eagle Lake, in which sudden and violent outbreaks accompanied the formation of large groups of infested trees in 1934 and 1935, losses were considerably lighter in 1935 or 1936. However, where that sudden fluctuation did not occur, or where no large groups of infested trees were formed, there either has been a steady though relatively slight decrease during 1935 and 1936 or a slight decrease in 1935 has been followed by a slight increase in 1936.

It is extremely difficult to determine the general infestation trends in this management unit and to make general forecasts based on the indications of future action by the insects. However, present insect activity is great and, although peak losses in this infestation cycle appear to have occurred in 1934, it is believed likely that heavy losses are yet to be recorded for some of the infestation units.

Eastern Plumas Working Circle - Plumas National Forest

The forest insect survey samples about 93,000 acres of virgin timber by biennial cruises. Although the 1935 loss record has not yet been completed and the 1936 losses will not be cruised until 1937, observations

indicate that the infestations have been decreasing in intensity during the past two seasons. The peak of the infestation cycle occurred in 1933. In that year the average cruised loss was 231 board feet per acre.

Review of Infestation Trends - Eastside Subregion

For a long period of time forest insect infestations have been active factors in reducing forest capital and in modifying stand conditions in the eastside subregion. However, there are no indications that previous series of infestations have equaled those that have been studied in extent, amount and continuity of depletion, or destruction of values. A gradual extension of epidemic infestations and of stand depletion in the eastside subregion is illustrated by the loss record that is available for study.

Heavy losses appeared first in the northern Shasta area where losses of as much as 190 board feet per acre were cruised in 1909 on plots in the vicinity of Bray. Similar excessive drain on forest capital was reported in connection with control projects carried on in that same general area by the McCloud River Lumber Company (1913-15) and the Weed Lumber Company (1920-24).

If it is possible to judge the past by present indications, losses on the fringe type of the Modoc must have started soon after epidemic infestations first appeared in the Shasta. In 1933, Jaenicke noted that heavy losses were resulting from epidemic infestations in the northern part of the Happy Camp-Lava Beds area of the Modoc. However, in that year infestations in the southern part of that area were relatively light. Since 1933, infestations in the southern part have been increasingly heavy until, during the past few years there have been relatively few points of difference between infestation conditions in the northern and southern parts of the area. The chief visible difference is that the accumulation of dead trees is greater in the northern part, where epidemic infestations have resulted in heavy losses over a longer period of time.

Similarly, there has been a gradual spread of epidemic infestations into the Lassen. Marked depletions of timber resources had occurred by the time systematic surveys were initiated in the Lassen areas. However, those depletions were, for the most part, confined to the fringe types of timber and to the southern exposures where environmental conditions favored insect activity. The period of record is sufficient to show the gradual extension of heavy losses into the better quality timber. Although no cruise records are available to illustrate further extension, it has been noted that active infestations have occurred within the past five years in stands near Battle Creek, Viola and Montgomery Creek. The timber in those localities is typical of the better type that occurs in the westside subregion. Ordinarily, infestations in that type of forest attract little attention because of their endemic character.

Westside Subregion

The westside subregion includes the forested areas bordering the San Joaquin and Sacramento Valleys on the east. Similar type and climatic influences may extend the northern boundary of the subregion so that it includes the stands from the McCloud River Basin south to and including the Sequoia National Forest. Records from this subregion are confined almost entirely to samples of about 296,000 acres in the Stanislaus National Forest and 72,000 acres in the Sierra National Forest. However, reconnaissance cruises have furnished general information on infestation conditions in other parts of the subregion.

The surveyed areas in the westside subregion have experienced infestations and trends that have been markedly different from those that have been affecting the eastside forests. The extent of the yearly fluctuations has been much greater, and their character has been different. The depletions that have resulted have been much less continuous. The outbreaks and peak infestations have been much more spectacular.

In spite of the fact that definite survey information is not available for many large or valuable basins of timber in the westside subregion, it is known that losses in timber and recreational areas have been much greater than normal. In western portions of the Lassen National Forest unusually active infestations have been observed in recent years. This activity appears to be the result of an extension of insect activity from the eastside subregion. In the American River Canyon on the Eldorado National Forest, as well as around Echo Lake on the same forest, some recent infestations in ponderosa, sugar, Jeffrey and lodgepole pines have required control action. Loss in fir in the Lake Tahoe region has been the source of much concern to owners of summer homes. On the Sequoia National Forest, particularly at Camp Nishom and Camp Nelson, the depletion of stands has been rapid and fairly continuous. During the past three years infestations in the Sequoia and Yosemite National Parks have required the expenditure of about $60,000 in controlling depredations of forest insects in the pine forests.

Stanislaus National Forest

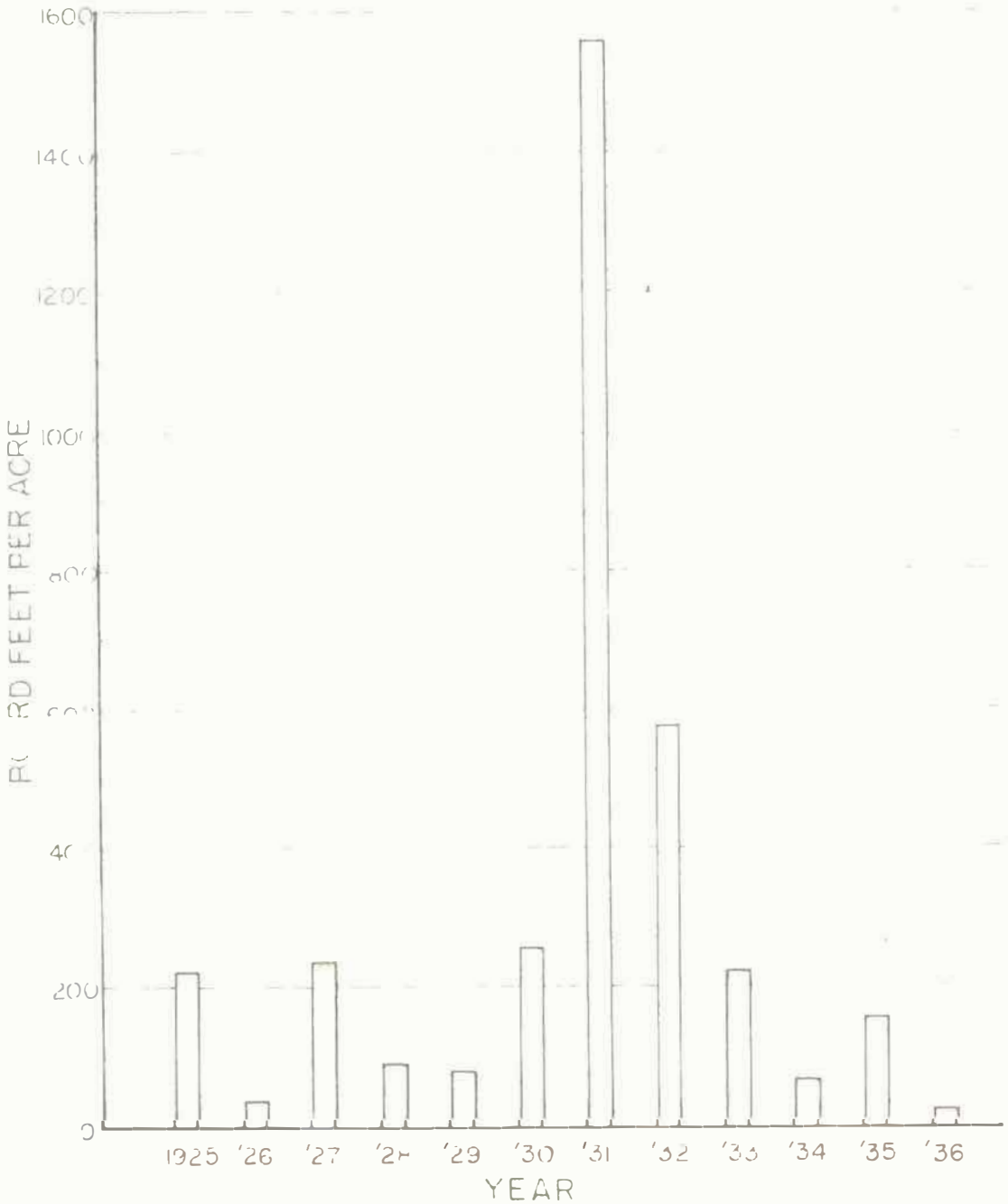
Infestations on approximately 296,000 acres that are located within or adjacent to the boundaries of the Stanislaus National Forest, have been sampled during the past three years. This acreage is scattered from the Merced River drainage on the south to the Mokelumne River drainage in the north in the form of relatively small infestation units. At the present time it is impossible to group these into larger management units.

In general, infestation conditions in the ponderosa pine and in the sugar pine-ponderosa pine forest types that have been sampled by plot and reconnaissance surveys, have been very similar to those that will be mentioned in the discussion of loss records for areas in the Sierra National Forest. Outbreaks in 1931 and 1932 were spectacular, particularly in the pure ponderosa pine type. Losses in both ponderosa pine and sugar pine have shown a fairly consistent decline since then. In spite of this, the most

FIG 4

PLOT LOSS RECORD

CASCADEL, SIERRA NATIONAL FOREST, CALIFORNIA



recent estimates available - those for the 1935 season - show that the so-called endemic infestations of that year killed some 15 million board feet of timber.

San Joaquin Drainage - Sierra National Forest

Samples of two distinct types of infestation conditions have been made in this drainage system. In the so-called "front" areas, which carry a ponderosa pine type forest cover, the record (Figure 4) from the Cascadel plot serves to illustrate infestation trends and conditions during the past 12 years. Although control work appears to have increased the rate of decline in losses following the 1931 peak, the record is fairly typical of the general infestation trends of nearby untreated areas.

PLOT LOSS RECORDS
Cascadel

Year	B.M. Destroyed per Acre
1925	220.5
1926	37.1
1927	236.9
1928	90.5
1929	77.5
1930	259.0
1931	1,557.5
1932	575.7
1933	222.2
1934	66.1
1935	155.1
1936	20.0 (tent.)
Total - 12 years	3,318.1

Many green trees were topkilled in 1924, 1925 and 1926 as a result of engraver beetle attacks. It is probable that the topkilling had considerable influence in causing the relatively heavy infestations and losses that have been recorded for 1925 and 1927.

Similar topkilling activity, caused by an engraver beetle (Ips confusus Lec.) was concerned in the increase in loss that occurred in 1930, and with the epidemic infestations that continued through 1931 and 1932. In 1933, topkilling activity had become greatly diminished. Trees that were particularly susceptible because they contained active infestations in the upper bole region were less numerous. Losses, which had been caused chiefly by infestations of the western pine beetle in the boles of previously topkilled trees, rapidly became lighter. The decrease continued through 1934. However, unexplainable activity on the part of the western pine beetle caused a temporary flare-up in 1935 that has been followed by endemic infestations in 1936.

The trends shown by the survey record for the Cascadel Plot were followed rather closely in other areas in the ponderosa pine type.

However, in the sugar pine-ponderosa pine type, which is sampled by plots in the Chiquito Basin, the fluctuations were less marked, losses did not reach as high a level and the resumption of endemic infestation conditions appeared to take place in 1934.

King's River Drainage - Sierra National Forest

Plot samples in the pure ponderosa pine type of this basin showed that the same general trends that have been reported for the San Joaquin drainage occurred in the King's River areas. The peak loss, which occurred in 1931, amounted to 1,373.9 b.m. per acre in the Blue Canyon basin.

A markedly different cycle occurred in the valuable ponderosa pine type forests of this area. The Fence Meadow plot, which samples that type, has the following loss record: -

PLOT LOSS RECORD
Fence Meadow

Year	B. M. Destroyed per Acre
1930	437.7
1931	1,100.2
1932	2,048.8
1933	563.7
1934	135.0
1935	411.9
1936	Loss not yet cruised
Total - 6 years	4,697.3

Unlike the loss record in the ponderosa pine type, the upward trend, which was evident in 1931, did not reach a peak until 1932. Observations on the behavior of infestations in the sugar pine-ponderosa pine type indicate that the 1932 peak loss was due directly to a combination of topkilling, epidemic infestation tendencies within the type, and a considerable influx of barkbeetles from nearby heavily infested ponderosa pine type stands.

Review of Infestation Trends - Westside Region

Although two infestation cycles are present in the 12 year record, that of 1925-1927 was, in comparison with the later cycle, scarcely more than a minor fluctuation. The infestation cycle which extended from 1930 through 1933 was of unprecedented intensity and resulted in greater insect caused losses than have ever been recorded in the westside subregion. Topkilling was prevalent throughout the ponderosa pine type in the Stanislaus and Sierra areas during 1930. The injury was chiefly the result of attacks by Ips confusus Lec., a species of engraver beetle. The topkilling activity during 1930 was followed by much greater activity in 1931. Peak losses occurred in most areas in that year. The infestations were spectacular and impressive. Large groups of infested trees were formed. Most of the infested areas. The decline in infestation intensity, which became evident in 1932,

appeared to follow a cessation of topkilling activity. Western pine beetle populations decreased rapidly following a reduction in the number of recently topkilled trees available for infestation. Endemic infestation conditions returned in 1934.

With a few exceptions, the spectacular outbreaks typical of the ponderosa pine type stands, did not occur in the sugar pine-ponderosa pine type. However, in many areas bearing stands of that type, impressive losses resulted from extremely active infestations. Losses in sugar pine, added to those caused by the increased though not spectacular activity of the western pine beetle in ponderosa pine, caused the figures for volume of loss to be much higher than was indicated by the appearance of most of the infestations.

Southern California Subregion

In general, it may be stated that all pine stands in Southern California are susceptible to insect damage. This is true partly because of the intensive use and abuse that is given them by man. However, the chief factors contributing to the hazard are natural. The stands are islands of timber of limited extent. They are confined to small areas in which local environmental conditions permit the existence of the tree species. They are exposed on all sides, or in some localities, over their entire area to factors that favor the insects and distress the trees.

No systematic survey has ever been made of the isolated and small bodies of timber that comprise the Southern California subregion. From 1925 through 1928 the Bureau of Entomology and Plant Quarantine cooperated in surveys and control of forest insects in the Lake Arrowhead area. In 1931 and 1932, similar work was done at Big Bear, Idyllwild, Laguna, Pine Valley and Corte Madera. In 1933 and 1934 the CCC program included insect control projects. These resulted in the treating of about two and a half million board feet of infested timber on the San Bernardino and Cleveland National Forests. In 1936, the Bureau made a reconnaissance of conditions in the recreational areas in the subregion, estimated infestation trends and recommended control action where it was considered necessary.

Throughout this series of reconnaissance surveys and control work, which has left no definite record of the amount of loss caused by insect activity, there has been no indication of widespread infestation cycles. In 1930, an outbreak occurred following a fire in Dyche Valley on Palomar Mountain. In 1931 and 1932, spectacular outbreaks occurred near Julian and Pine Hills. In 1936, an outbreak appears to be in the process of development in the Cuyamaca State Park. Losses appear to be increasing in the Lake Arrowhead area. However, these local infestations do not appear to be a part of any subregional trend. Most of the infestations in ponderosa and Jeffrey pine that have been examined in this subregion appear to be active endemic types. This is a type of insect activity that can cause irreparable damage to recreational areas for the depletions are continuous and heavy, although they are relatively unimpressive in appearance. However, infestations in Coulter pine stands have included spectacular outbreaks and the formation of large groups of infested trees.

MISCELLANEOUS SURVEYS

Barkbeetles

The three National Parks in California lie in the westside subregion. The Bureau of Entomology and Plant Quarantine has cooperated with the National Park Service in building up adequate detection and control systems for the timber lands with the boundaries of each park. Previous to 1932, most of the field work that had to be done in order to secure adequate figures on losses, was accomplished by the Bureau. Since 1932, the National Park Service personnel has taken over much of that work, although the Bureau personnel continues to make examinations, and members of the Berkeley Laboratory staff act as technical advisors on National Park survey and control projects.

A number of sporadic surveys of individual infestation units have been made in both the eastside and westside subregions. In addition, reconnaissance work in the pine type of the coast range has furnished a very fragmentary record of infestation conditions. One such survey, which was made in July, 1936, by Mr. J. E. Patterson, revealed that a few epidemic centers of infestation were present in the fringe type stands in parts of the Shasta, Klamath and Mendocino National Forests. From observations made during that survey, it has been concluded that, during the past few years, losses in the coast range stands have been heavier than normal. The peak of the infestation cycle was reached in 1933. The infestation intensity, with the exception of that in some areas of limited extent, was not high.

In most areas the reconnaissance type of work has been carried on for but a single season. For the most part the work has been done in response to requests for information on forest insect conditions in specific areas. This sporadic type of work has produced variable results. Its chief value, besides giving an immediate general answer to the questions of how much loss has or is occurring and what infestation trends exist at the time the work is done, has been in illustrating how varied infestation conditions may be in different areas, even in the same year. The results have served to demonstrate the need for a more adequate coverage of the timbered areas of the state by a systematic forest insect survey.

Other Insects

Lodgepole Needleminer

Previous epidemic infestations by Recurvaria milleri Busck, which were followed by mountain pine beetle attacks in infested areas, have caused the formation of extensive "ghost forests" of snags. These forests, which are the result of excessive or successive defoliations by the needleminer, are well-known landmarks in the Tuolumne Meadows and Tenaya Lake areas of the Yosemite National Park. In 1931, in connection with a reconnaissance survey of lodgepole areas in the Park, it was found that the infestation intensity was increasing in some stands. Subsequent surveys, made in 1933 and 1935 by the National Park Service revealed that epidemic infestations

existed in Rodgers Canyon, Bear Valley and Forsyth Pass. Heavy infestations were found near Merced Lake and Porcupine Flat. The insect has been found in several areas in which it had not previously been known to occur. Inasmuch as the species has a two year life cycle, there have been no changes in the infestations during 1936.

Fir Tussock Moth

Defoliation of the tops of small and large fir trees near Mammoth and in the Modoc National Forest was an unusual feature of the 1936 season. The species involved is believed to be Hemerocampa oslari (Barnes). Few adults emerged in the fall of 1936, although large numbers of larvae were present in the infested areas and, in one area in which successive observations have been made, most of the larvae pupated successfully. Many pupae were parasitized. Observations made in September revealed that many of the egg masses contained few healthy eggs.

Pine Tipmoth

In 1934, it was discovered that a pine tipmoth, believed to be Rhyacionia zozana (Kearf.), was causing considerable damage to pine reproduction in several parts of the state. It was found to be very abundant in parts of the eastside subregion. There were evidences that the species was fairly active in some of the pure ponderosa pine stands of the westside subregion. Observations that were made in 1935 and 1936 in the Modoc National Forest indicated that the species is continuing its activity in that area at an undiminished rate.

APPLICATION OF SURVEY RESULTS

The forest insect survey results that have been secured have furnished definite answers to two questions that are asked by timber owners or administrators of forested lands. These two questions are (1) How much timber is being killed by forest insects on my lands? and (2) What are the potentialities of the current infestations?. These questions have been answered with considerable accuracy if the timber lands on which the information is desired lie within or adjacent to the areas sampled by plots. The answer has been less accurate in areas that have not been included in the intensive surveys.

In addition to performing that service to forest owners and administrators, the forest insect survey has had direct application in several other ways.

Direct Forest Insect Control

Survey results are used in determining when and where insect control should be practiced. They also are used in determining costs, how much work will have to be done, and what results are secured. During the past ten years, survey results have been used in planning forest insect control projects on private lands, National Forests and National Parks. Those plans have resulted in the treatment of infestations on about 560,000 acres at a cost of about $328,000.

Maintenance Control

Reconnaissance and plot surveys have been applied in planning maintenance control programs for recreational areas. This work has been of particular application in National Parks and in the Southern California subregion.

Salvage Logging

Surveys have provided basic data on which expenditures for salvage logging have been made. At the present time, they are used in determining when and where salvage logging should be practiced on one government timber sale. Their use is now being extended to apply to other areas.

Management Plans

Regional survey results have been used in modifying utilization plans on one working circle. They have justified the order of utilizations on another. They have been used by the Forest Service in checking their own reappraisals of stand figures.

Zonation of Hazard

During 1936, a start was made in outlining the basis on which a determination of hazard from future outbreaks and losses could be made. Preliminary analysis of the data taken in connection with that work indicates that survey information may be sufficient for the delineation of areas of different hazard, particularly if the zonation be made on a relatively broad basis. A more specific zonation may be possible when a better coverage of forested areas has been attained.

PLANS FOR FURTHER WORK

An analysis and summary is made of the results that are obtained from the survey of each plot, infestation and management unit. The information resulting from that work, comments on the character of infestation conditions, and recommendations for the treatment of infestations is prepared in report form for each area that is covered by intensive methods. A more general type of report is prepared following each reconnaissance survey. These reports are distributed to the individuals or agencies that cooperated in the work and to others known to be interested. Plot loss summaries are prepared in table form for insertion in a survey atlas. Estimates of losses in each infestation and management unit are recorded in a similar table. This information can be made available to those desiring definite figures on insect losses or analyses of conditions for the period during which records have been taken.

It is our intention to continue to make surveys of the areas that already have been covered by intensive work. That activity fulfills the minimum requirements of the job. It is the maximum amount of work that can be done on the resources that are available for the project. However, it is

realized that sampling of infestations in but two of the four subregions gives an insufficient basis on which to judge infestation conditions and potentialities in all four. It is realized that sampling of infestations in but a fifth of the commercial pine timber does not give satisfactory data on which to base plans for the management of commercial forests. It is realized that a sample of but a sixteenth of the total forested area in the state gives little basis for preparing region-wide or comprehensive programs for the prevention and control of insect-caused losses in the forests. Accordingly, although present resources are not sufficient to provide for an adequate organization, it is believed that plans for future work should fit the job that needs to be done. The following five points are outlined as necessary elements in the attainment of an adequate and comprehensive annual regional survey of forest insect depredations.

1. Analysis for improvement of sampling methods

Before the survey is extended to other areas it is advisable that we examine our present methods of sampling by means of plots or strips and determine if less time-consuming methods could be used that would yield results of equal accuracy.

2. Examination of methods of applying sample plot results

The accuracy of estimates derived from samples rests largely on the methods of extending the plot records to larger areas. This phase of the work should be examined in connection with that suggested under point 1. Tests should be made of the value of autogiros and airplanes in applying the results of detailed ground work to larger areas.

3. Organization of infestation and management units

Infestation unit boundaries are selected because of entomological considerations. Management unit boundaries are selected because of logging, management, administrative or type boundary considerations. It is necessary to consolidate and organize the plot samples and infestation units so that the basic information secured for the two smallest elements of the survey system will be adaptable for application to the larger units.

4. Examination and organization of analysis and recording methods

One of the chief criticisms usually made of quantitative information that is gathered year after year, is that its basis and its analysis does not remain the same. Because of this it often is impossible to compare the results of the work of different seasons. A start has been made in setting up uniform methods for analysis and presentation of information gathered from the plot samples. Before the project is enlarged, present methods of analysis and presentation of data from the larger units should be studied carefully. Such changes as appear to be necessary should be made and standardized methods should be evolved.

5. Extension of survey to unsurveyed areas

a. There are many areas in which epidemic infestations have occurred in recent years but of which there is no record of infestation trends, of potential losses, or of the amount of injury that has resulted. Such areas should be the first to be included in the regional survey.

b. We have taken a few samples in areas of moderate hazard. We know little of the behavior of infestations or of the total amount of loss that accumulates from the occasional outbreaks or the continued endemic infestations in these areas. Infestations on these areas are a potential hazard and cannot be overlooked.

c. No samples have been taken of infestation conditions in the coast range. However, it is known that many areas in that subregion can be classed in the group of moderate hazard. Some are areas of high hazard. Samples of both types should be taken by the regional survey.

d. The investments that have been made for recreational facilities in the forested areas of Southern California and in other recreational centers necessitate definite knowledge of the potential destructive power of each year's infestation as well as the development of methods and plans for the protection and management of the areas. An annual survey of infestations in such areas should be coordinated with work on the development of adequate methods for the prevention and control of infestations.

e. Most of the plots now included in the Regional Survey are in ponderosa pine or sugar pine-ponderosa pine forest types. Information on the mixed conifer and fir types should be secured if a correct evaluation is to be made of the effects of insect depredations in those types.

f. Twenty-five sample lots have been established in cutover areas. A better coverage of such areas is necessary. Results that have been secured to date indicate that, under some conditions, depletion of the reserve continues at an undiminished rate after logging. Inasmuch as one of the primary objectives of selective logging is to leave a reserve that is capable of increment, long term survey records and measurement of environmental factors are necessary in evaluating the effects of entomological factors as well as in determining the success of silvicultural methods.